The Alignment of 6300A Airglow Isophotes in the Tropics[1]

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From the observations of a scanning photometer at Haleakala [Barbier, Roach, Steiger, 1962] 6300A airglow isophote maps have been produced. Figures 1 and 2 show sample maps. These isophote maps can be roughly classified into two types: (1) Those that show a "spotty" character, with at least some of the isophotes making closed loops, as in Figure 1; and (2) those that show a somewhat "aligned" character with the isophotes roughly linear and parallel to each other, as in Figure 2.

The spotty character is often associated with the localized tropical enhancements that have been discussed by a number of workers: Barbier [1964]; Barbier, Roach, Steiger [1962]; Carman & Gibson-Wilde [1964]; Davis and Smith]1965]; A. & D. Delsemme [1960]; Saito [1962]; Silverman & Casaverde [1961]. Aligned isophotes are often associated with morning and evening twilight effects as evidenced by their orientation with respect to the sunset or sunrise directions, but also during the middle of the night isophote alignment of the nightglow is often evident.

In order to test whether the nightglow alignments are random or ordered, the observing night was divided into three parts: (1) The "evening" period

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from twilight to 1955; (2) the "midnight" period from 2155 to 0255; and (3) the "morning" period from 0410 into twilight. For each 15-minute interval during these periods for which an isophote map was available a determination was made as to whether the map was spotty or aligned. If aligned, the direction of alignment in the vicinity of the zenith was determined, the direction being specified in terms of the direction of the airglow intensity gradient. For example, in Figure 2 the direction of the alignment is specified by the intensity gradient at an azimuth of 198° East from North. Henceforth in this paper "direction of alignment" shall refer to this azimuth of the airglow intensity gradient.

The analysis of 3,451 isophote maps from July 1961 to July 1962 showed that 1,111 possessed an aligned character, and of these 193 were during the evening period, 735 were during the midnight period, and 183 were during the morning period. The distribution is shown in the following table:

	Evening	Midnight	Morning	TOTAL
No. of maps	289	2,465	697	3,451
No. of aligned maps	193	735	183	1,111
Percent aligned	67%	30%	26%	32%

Figure 3 illustrates the frequency of occurrence of alignments during the year for the midnight period. Evidently they occur somewhat more frequently during the fall months than during the rest of the year. This is also the period when the average 6300A airglow reached its seasonal photometric maximum.

In Figure 4 is plotted the direction of each evening alignment during the year. The solid curve on the graph represents the azimuth of the setting sun. It is seen that the general trend of the alignments is to follow the solid curve, indicating that the gradient of the evening airglow points in the general direction of the setting sun, as one might expect. What is surprising, however, is that the gradient does not point exactly in the direction of the setting sun, but somewhat to the north of the setting sun in the summer months and somewhat to the south in the winter months.

The results for the morning period are plotted similarly in Figure 5. Again, the same general conclusion follows: That the gradient of the airglow points in the general direction of the rising sun, but in this case there is a rather consistent tendency to be somewhat south of the rising sun.

The midnight period maps show alignments in all directions but a very high preponderance in the range of 190° to 200°, as shown in Figure 6. Shown also is the azimuth of the horizontal component of the geomagnetic field, 11° E of N.

One sees at once that the predominant direction of the isophotes is perpendicular to the direction of the geomagnetic field, with the gradient parallel to the field direction, increasing from north to south. Another way of stating this is that the 6300A isophotes tend to be aligned with the isoclines. It seems unlikely that this is a coincidence and, in fact, it is consistent with the concept of geomagnetic control of the 6300A emission, as well as of the F region of the ionosphere in the domain of the so-called equatorial anomaly [Barbier, Weill, and Fafiotte, 1961; Appleton, 1954]. Historically, geomagnetic control of optical emissions has been associated with aurora, in contrast with the airglow which is usually considered to be due to reactions in situ which are not sensitive to the earth's magnetic field. The geomagnetic control effective in the case of the equatorial anomaly probably is one of guidance of gentle ionization from the equator down along the field lines [Duncan, 1960], in contrast with the polar aurora where the more energetic charged particles effective in producing optical emissions escape from their magnetic trap en route to their optically effective domain near 100 km. The effective height of the 6300A nightglow in the tropics is about 250 km [Barbier, 1964] and it is probable that the contribution of the magnetic field is to guide ionization to the 250-km region. That the optical emissions are associated with F-region recombination processes has been suggested by many investigators [see for example Peterson, VanZandt and Norton, 1966].

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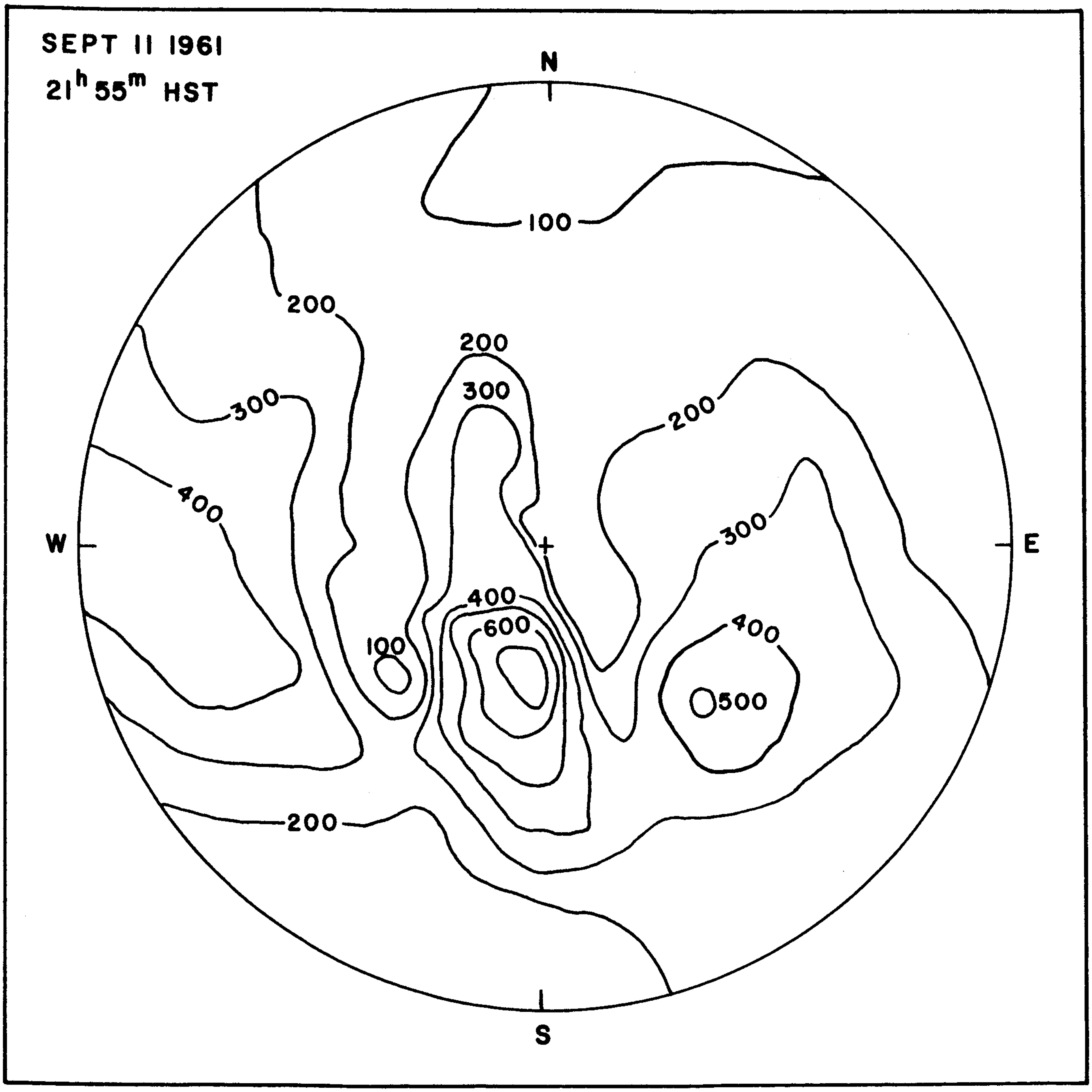
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Figure 1

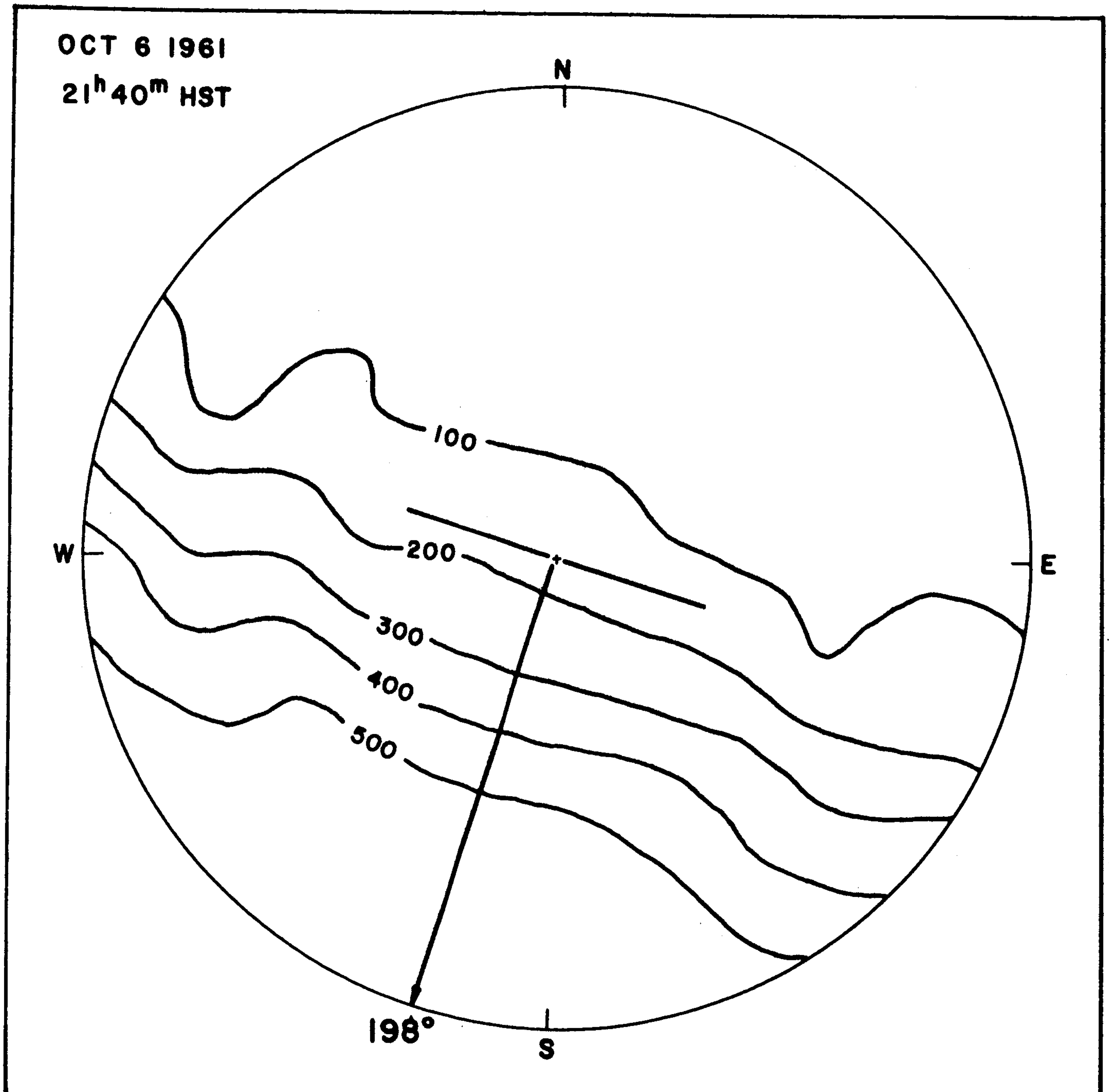
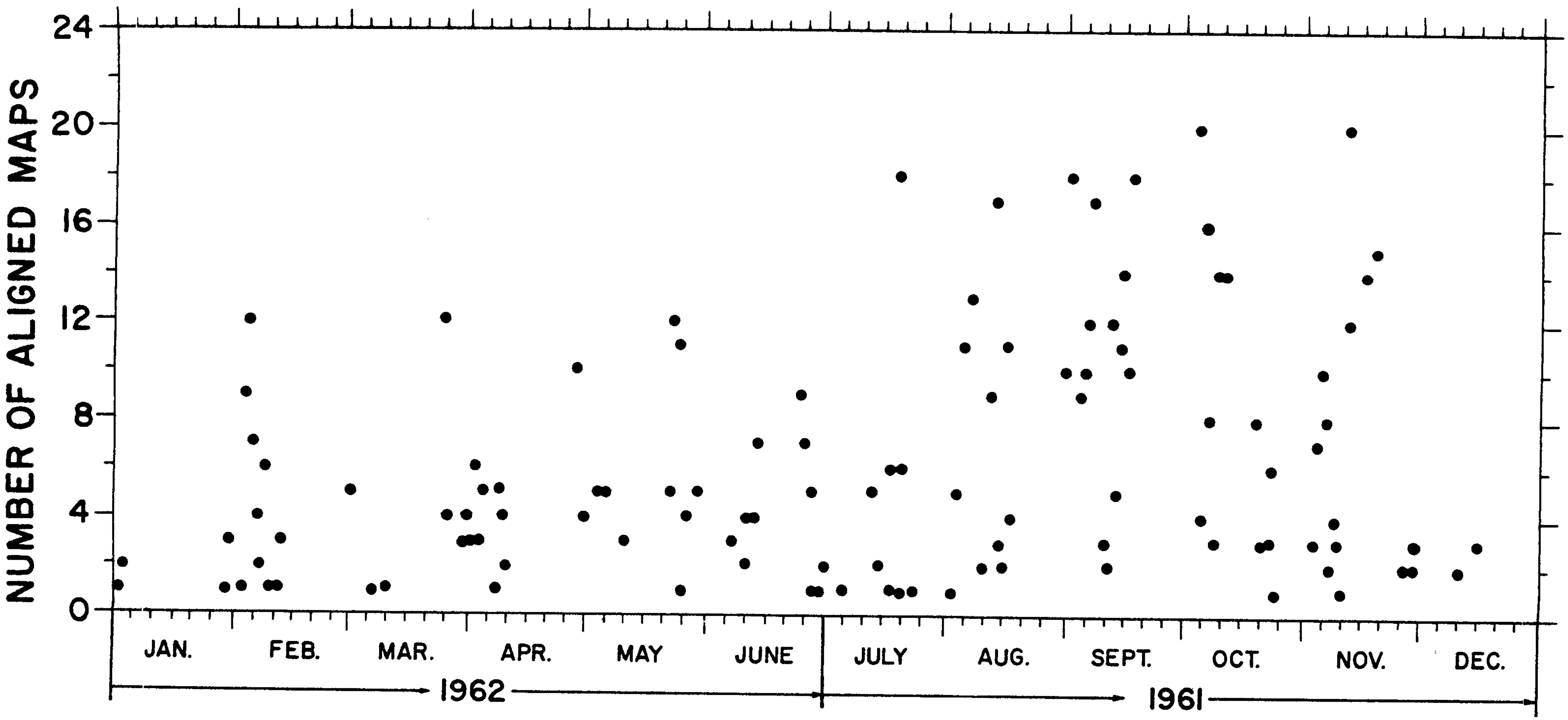
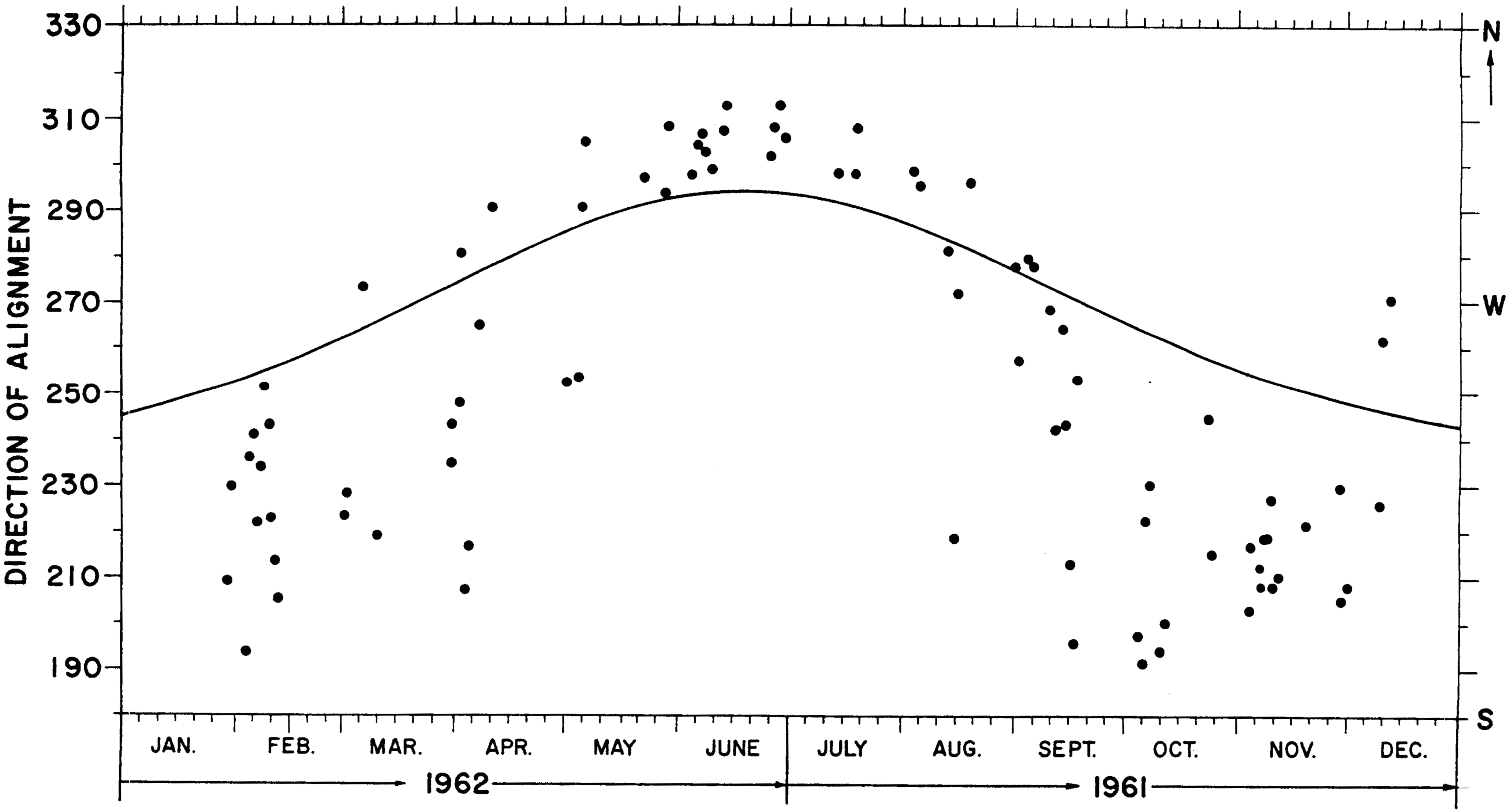


Figure 2



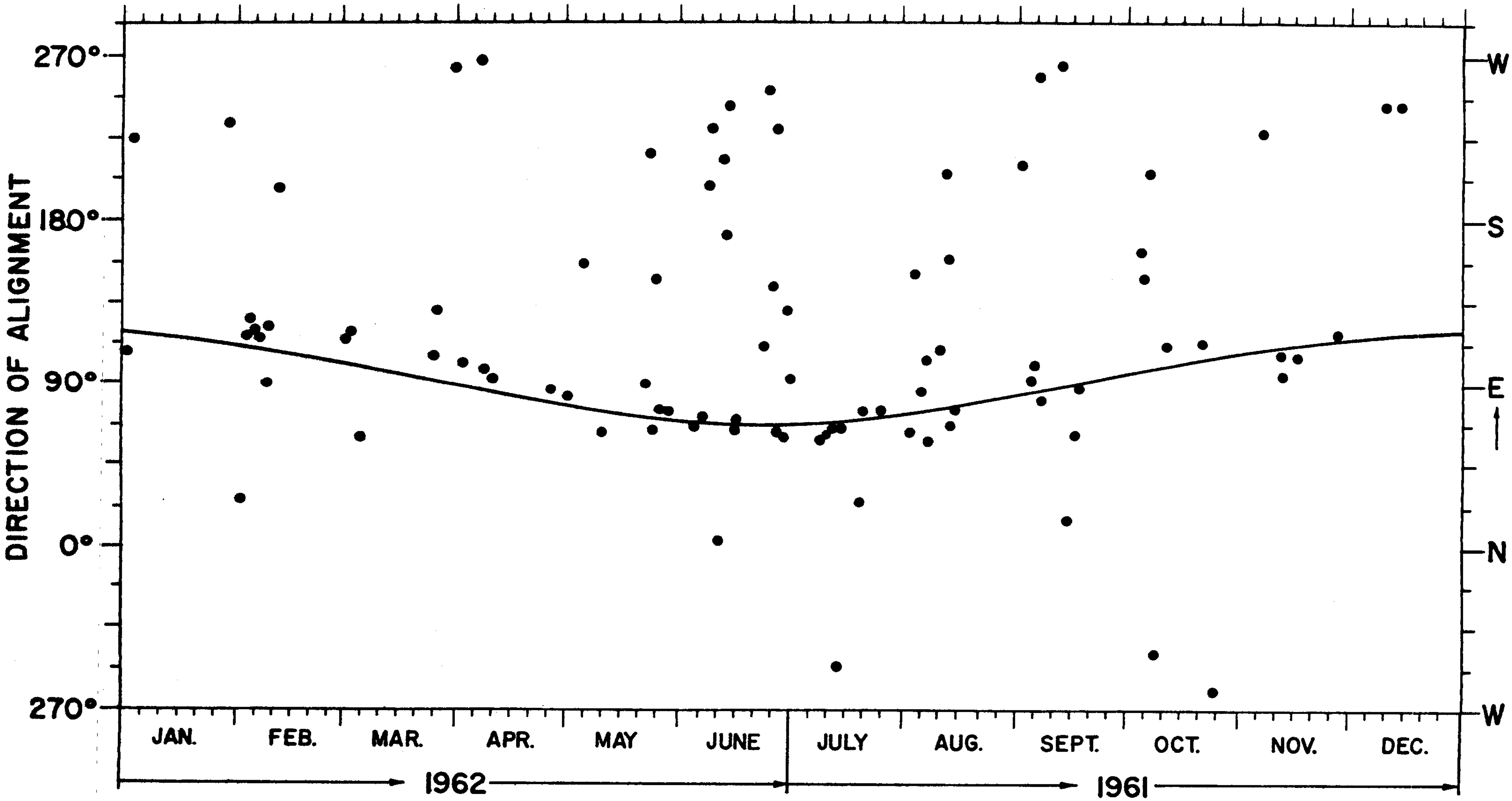
JULY 1961 TO JULY 1962

Figure 3



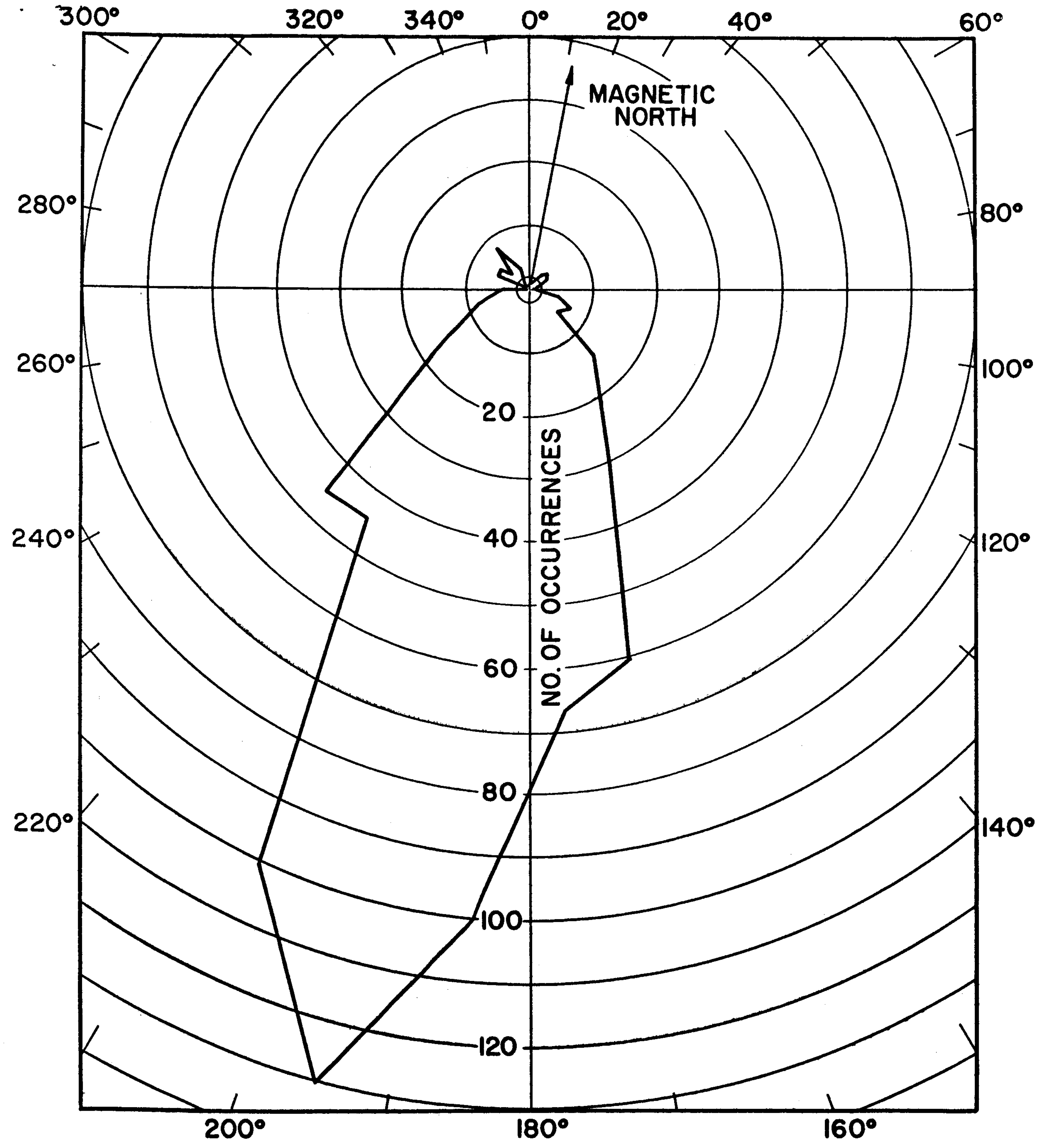
JULY 1961 TO JULY 1962

Figure 4



JULY 1961 TO JULY 1962

Figure 5



300°
320°
340°
0°
20°
40°
60°
MAGNETIC NORTH
280°
80°
260°
100°
240°
120°
220°
140°
200°
180°
160°
20
40
60
80
100
120
NO. OF OCCURRENCES

Figure 6